African Invertebrates Vol. 42 Pages 323–334 Pietermaritzburg December, 2001

Notes on the occurrence of the introduced earthworm *Pontoscolex corethrurus* (Müller, 1857) in South Africa (Oligochaeta: Glossoscolecidae)

by

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ABSTRACT

An account is given of the range of the introduced allochthonous species *Pontoscolex corethrurus* (Müller, 1857) in South Africa. Its distribution is restricted to northeastern parts with relatively high rainfall, and to sites in or close to urban areas, or with adjacent agricultural developments. Occurrence is associated with exotic plants including those in plantations, gardens, horticultural developments, arable lands and pastures. The species seems to have a very limited capacity for dispersal.

The potential of this species for applications in agronomic-practices in South Africa will require assessment in relation to possible limiting factors.

INTRODUCTION

The glossoscolecid *Pontoscolex corethrurus* (Müller, 1857) was described from Itajahy in Brazil, and is commonly considered to be indigenous to northeastern South America. According to Gates (1973), the original home of this species should be 'somewhere in the American tropics'. Righi (1984) indicates Guiana plateau to be the endemic area for the whole genus *Pontoscolex* Schmarda, 1861, and thus also for its type species *P. corethrurus*. Dyne & Wallace (1994) are of the opinion that Amazonian Brazil was its original territory. The exact endemic territory is difficult to establish because this species has been found in many tropical and subtropical localities, and also commonly noted from greenhouses on most continents. Its widespread distribution is attributed to accidental introductions due to human activities. In recent years, much new information has accrued due to increasing interest in the possible role of *P. corethrurus* in agroecosystems. During the last few decades, numerous experiments were conducted on the allochthonous earthworms (foreign species, introduced either deliberately or accidentally), including *P. corethrurus*. These studies suggest not only that this species adapts easily to new environments, but also confirm its occurrence in 56 countries in South and North America, Africa, Asia and Australia (Fragoso *et al.* 1999; Brown *et al.* 1999). Long listings of numerous records can be found in many papers, in which the authors usually refer to *P. corethrurus* as 'cosmopolitan' or 'peregrine' (Lee 1987; Edwards & Bohlen 1996). Gates (1972 1973) and Righi (1984) collected from numerous large populations in inland territories, far from the coast, suggesting that this species could easily expand its range. Some authors, however, were of the opinion that it has a preference for tropical and subtropical coastal habitats (Stephenson 1930; Ljungström 1972).

In South Africa, *P. corethrurus* was recorded by Michaelsen (1913), Ljungström (1972), Reynolds & Reinecke (1976), Zicsi & Reinecke (1992) and Plisko (2000), on single samples, or among small collections. Reynolds (1993) recorded it from Swaziland in six localities. The aim of this paper is to widen knowledge of its occurrence in South Africa, and to identify possible limitations on its distribution.

MATERIAL AND METHODS

During my extended investigations of megadrile earthworms in South Africa for taxonomic and ecological studies, concentrating on the indigenous species of Microchaetidae and Acanthodrilidae, the introduced species were also collected. To date, 178 samples containing over 2000 specimens of *Pontoscolex corethrurus* (Müller, 1856) were secured for the Natal Museum Oligochaeta Collection. This material is recorded below, and the localities are shown in Fig. 1. Identifications were based on alcohol-preserved material. Data obtained from re-examined material studied by previous authors are cited in square brackets. Previously published information referring to localities is listed below, with the correction of spelling of the locality names if necessary, and co-ordinates in square brackets when it was possible to establish them.

Province names in the text are in accordance with those accepted and used since April 1994. Mpumalanga was formerly known as the Eastern Transvaal, and Gauteng is part of the province previously known as the Transvaal. The Kruger National Park is listed as a region separate from the two provinces, Northern Province and Mpumalanga,

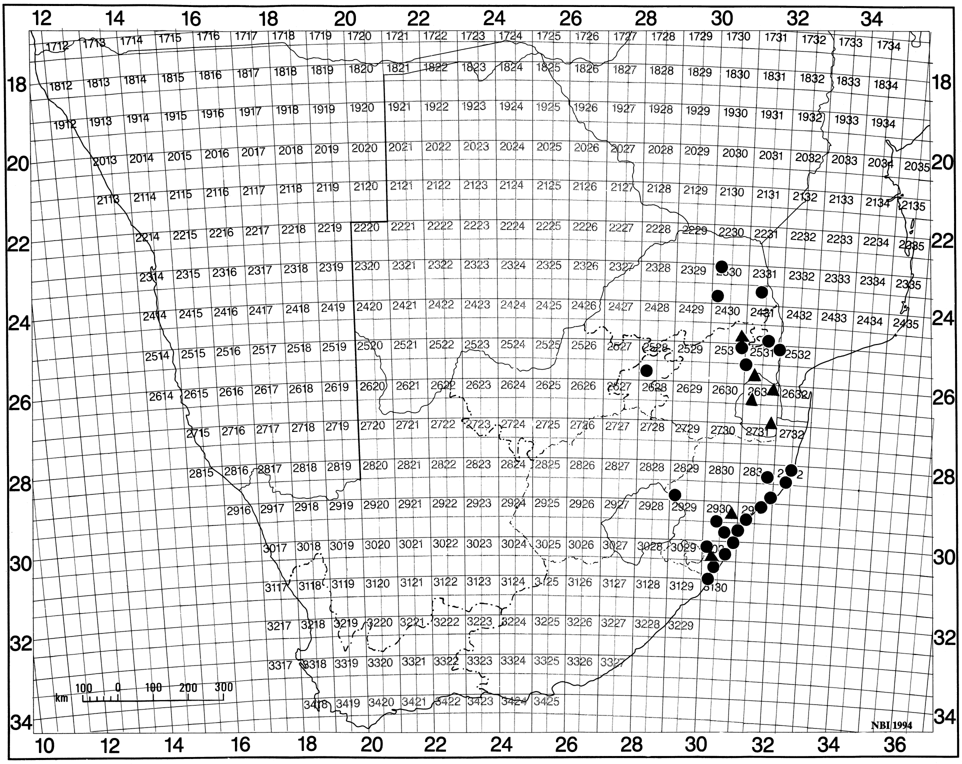

Fig. 1. Distribution of the exotic species *Pontoscolex corethrurus* Müller in South Africa. ● Species occurrence based on material in the Natal Museum Oligochaeta Collection. ▲ Localities known from the literature.

which border it. Material not from South Africa is listed separately.

Only a limited list of references is cited below; the extensive bibliography on *P. corethrurus* can be found in Gates (1972).

Abbreviations:

AJA	A. J. Armstrong
AJR	A. J. Reinecke
BRS	B. R. Stuckenberg
cl	clitellate specimens
juv	juvenile specimens
JDP	J. D. Plisko
JWR	J. W. Reynolds
NMSA	Natal Museum, Pietermaritzburg, South Africa
NMSA/Olig.	Oligochaeta Collection of the Natal Museum
OB	O. Bourquin
POL	P. O. Ljungström
PR	P. Reavell
TCD	T. C. Dlamini
TL	T. Liversage

Pontoscolex corethrurus (Müller, 1857)

Lumbricus corethrurus Müller, 1857: 113.

Pontoscolex corethrurus: Michaelsen, 1913: 422 (South African record); Gates, 1943: 92 (description), 1962: 140 (reproduction), 1972: 54 (distribution and description), 1973: 1 (distribution, description and reproduction); Righi & Bittencourt, 1972: 155 (distribution and systematic position); Ljungström, 1972: 7; Reynolds & Reinecke, 1976: 6–10; Zicsi & Reinecke, 1992: 157; Plisko 2000: 77 (South African data); Reynolds, 1993 (records from Swaziland); Edwards & Bohlen, 1996 (ecology and experimental application); Lavelle, Brussaard & Hendrix, 1999 (applications in agroecosystems).

Pontoscolex (*Pontoscolex*) *corethrurus*: Righi, 1984: 163 (distribution, systematic position).

External and internal characters observed in South African specimens accord with descriptions by Gates (1943 1962 1972 1973), although some irregularity in thickness of the preclitellar septa was noted. In the hind end of the worm, a swollen region comprising no more than 5–6 segments, called by Eisen (1896) a 'caudal zone', was rare; it was found only on seven specimens. Setae *b* and *d* on the posterior part of the body were always in the quincunx arrangement. Preclitellarly setae *ab* or *cd* on some individuals manifested variable distances. The absence of mature male gametes or rudimentary male organs, observed in all dissected specimens, suggest parthenogenetic reproduction.

MATERIAL EXAMINED

SOUTH AFRICA: *Northern Province*: Entabeni State Forest (23°01'S:30°15'E), collected by JDP & TL: near Timbadola from sandy soil, 9 December 1995,1 cl, NMSA/Olig.02255; near Forest Camp from fallow ground, moist sandy soil, 9 December 1995, 40 cl, NMSA/Olig.02249; on bank Lutanandwa River, from moist sandy soil, 10–11 December 1995, 2 cl + 9 juv, NMSA/Olig.02263, and 1 juv, NMSA/Olig.02258; at pine plantation near 'Klein Australia', 11 December 1995, from sandy soil, 10 cl + 14 juv, NMSA/Olig.02266, and 3 cl + 4 juv, NMSA/Olig.02265; from moist, red soil, 4 cl

+ 9 juv, NMSA/Olig.02268; on bank of stream, from moist soil, 15 cl, NMSA/Olig.02272; near Forest Station, from fallow ground topsoil, 10 December 1995, 80 cl + 8 juv, NMSA/Olig.02252, and 2 cocoons, NMSA/Olig.02339. Letsitele, on bank Letaba River (23°40'S:31°25'E), 4 April 1973, S. F. du Plessis, 26 cl + 12 juv, NMSA/Olig.01078. Tzaneen (23°47'S:30°09'E) area: on Tzaneen-Strydom Tunnel Rd, approx. 20 miles from Tzaneen, at small stream, 9 July 1967, AJR, 1 specimen, NMSA/Olig.01288; on bank Ramadipa River (23°50'S:30°10'R) near indigenous forest, dry soil, 13 December 1995, JDP & TL, 3 cl + 2 juv, NMSA/Olig.02275.

Kruger National Park: Skurakwane, between Numbi and Skukuza (24°59'S:31°35'E) on banks Sabie River, approx. 100 m S of Hippo Pool, dark brown-black clayey soil, 16 April 1975, JWR & AJR, 18 cl + 1 juv, NMSA/Olig.01096 [recorded in Reynolds & Reinecke 1976]. On bank Sabie River at junction of Phabeni River (24°59'S:31°49'E), from light, sandy soil,16 April 1975, JWR & AJR, 15 cl + 13 juv, NMSA/Olig.01095 [recorded by Reynolds & Reinecke 1976]. 13 km from Skukuza, near Lower Sabie road, 17 April 1975, AJR & JWR, 27 cl + 5 juv, NMSA/Olig.01075. On bank Sabie River, below Lower-Sabie (25°10'S:31°59'E) Rest Camp, from wet, rich, dark brown soil, with many casts on surface, 17 April 1975, AJR, 22 cl + 6 juv, NMSA/Olig.01079.

*Mpumalan*ga: Thalalanati, near Sabie (25°02'S:30°58'E), collected by JDP & TL: 14–15 December 1995, from topsoil of grassland near hotel, 11 cl + 16 juv, NMSA/Olig.02285, and from moist soil in pine plantation, 11 specimens, NMSA/Olig.02284. 30 km N of Nelspruit (25°28'S:31°00'E) near road, at eastern side hill covered by indigenous bush, from moist topsoil, 28 November 1996, JDP & TL, 11 cl + 33 juv, NMSA/Olig.02398. Nelspruit, on river bank, April 1967, AJR, 3 specimens, NMSA/Olig.01076. Nelspruit, 4 December 1972, SF du Plessis, 44 cl + 45 juv, NMSA/Olig.01074. 10 km E of Nelspruit near road to Malelane, in small swamp covered by indigenous bush, from moist soil, 15 December 1995, JDP & TL, 6 cl + 4 juv, NMSA/Olig.02293.

Gauteng: Pretoria (25°45'S:28°12'E): Greenhouse in Burgers Park, under pot-plant, 22 February 1977, JDP, 1 juv, NMSA/Olig. 03296; Groenkloof, Protea Park, from flower bed with various plants transported two days earlier from greenhouse, 15 March 1977, JDP, 16 cl + 1 juv, NMSA/Olig.03269.

KwaZulu-Natal: Eastern Shores Nature Reserve (28°11'S:32°30'E), logged and burnt pine plantation, from sand mixed with burnt, very wet pine debris amassed under pine log, 10 January 2000, OB, 1 juv, NMSA/Olig.02793. Umfolozi Game Reserve (28°22'S:31°52'E): Mpila Camp, occasionally watered vegetable garden, dry soil, 28 May 1995, JDP, 1 cl, NMSA/Olig.02104. On high bank White Umfolozi River, *ca.* 1 km from tourist camp, from primary grassland sandy soil, at 20 cm depth, 24 February 1990, JDP, 21 cl, NMSA/Olig.00642, and 6 abscised posterior parts, NMSA/Olig.00643. Mapelane Nature Reserve (28°26'S:32°24'E) at edge indigenous forest and grassland, moist sandy soil, 26 November 1996, JDP & TL, 3 cl + 16 juv, NMSA/Olig.02373. 7 km NW Melmoth (28°35':31°24'E) at side of road, fallow ground, 3 December 1990, JDP & BRS, 3 cl + 14 juv, NMSA/Olig.01049. 15 km S Empangeni (28°42'S:31°54'E) dry soil of cultivated land, 27 June 1989, JDP & PR, 6 juv, NMSA/Olig.00899. 8 km S Empangeni, riverine *Voacanga thovarsi* swamp forest, from clay, humus and roots of various plants, 27 June 1989, JDP & PR, 15 cl + 5 juv, NMSA/Olig.00852. Richards

Bay (28°50'S:32°08'E) from garden soil, 3 May 1998, BRS, 1 cl + 1 juv, NMSA/Olig.02751. Kwa Dlangezwa University of Zululand (28°51'S:31°51'E) fallow ground, 26 June 1989, JDP & PR, 1 cl + 2 juv, NMSA/Olig.00936. Swamp with rich soil, near University of Zululand, 26 June 1989, JDP & PR, 1 juv, NMSA/Olig.00948. Banana field, moist soil, 26 June 1989, JDP & PR, 11 specimens, NMSA/Olig.00950. Empangeni, Lighthouse Farm, collected by TCD, 12 April 2000, from topsoil under burnt sugarcane, sample 231, 8 juv, NMSA/Olig.03064. 14 April 2000, from topsoil under harvested sugarcane: sample 1214, 2 cl, NMSA/Olig.03042; sample 1215, 2 cl + 18 juv, NMSA/Olig.03044; sample 1216, 2 cl + 21 juv, NMSA/Olig.03046; sample 1217, 3 juv, NMSA/Olig.03047; sample 1219, 2 cl + 2 juv + 2 abscised parts, NMSA/Olig.03048; sample 1220, 1 cl + 4 juv, NMSA/Olig.03049; sample 1223, 1 cl + 4 juv, NMSA/Olig.03050. Entumeni Nature Reserve (28°52'S:29°22'E), in forest near compound, 1 March 2001, D. Eckard, 1 cl, NMSA/Olig.03363. Dlinza Forest Nature Reserve (28°53'S:31°26'E), indigenous forest sandy soil on bank stream near graveyard, 1 February 1989, JDP & BRS, 2 cl + 37 juv, NMSA/Olig.00883. Dlinza Forest Nature Reserve, indigenous forest, D. Harebottle: November 1991, 2 cl + 16 juv, NMSA/Olig.01959, and 24 juv, NMSA/Olig.01973; December 1991, 1 cl + 19 juv, NMSA/Olig.01966, and 2 cl + 11 juv, NMSA/Olig.01978; January 1992, 2 cl + 26 juv, NMSA/Olig.01980, and 3 cl + 18 juv, NMSA/Olig.01967; February 1992, 1 cl + 2 juv, NMSA/Olig.01971. Eshowe (28°53'S:31°28'E), collected by TCD: Benhurst Farm, under banana plantation, 14 April 2000, sample 319, 2 cl (caudal zone observed) + 4 juv, NMSA/Olig.03082; sample 324, 2 cl, NMSA/Olig.03084. Brooklee Farm, indigenous forest, 23 February 2000, sample 601, 1 cl + 1 juv, NMSA/Olig.03125; sample 602, 1 cl + 6 juv, NMSA/Olig.03127; sample 603, 8 juv, NMSA/Olig.03128; sample 604, 1 cl, NMSA/Olig.03132. Brooklee Farm, under gum trees, 23 February 2000, sample 802, 1 cl, NMSA/Olig.03143 and sample 804, 1 cl, NMSA/Olig.03144. Brooklee Farm, under burnt cane, 16 February 2000, sample 201, 5 juv, NMSA/Olig.03051 and sample 203, 2 cl + 4 juv, NMSA/Olig.03053; 23 February 2000, sample 205, 1 cl + 1 juv, NMSA/Olig.03054 and sample 206, 2 cl + 2 juv, NMSA/Olig.03055. Brooklee Farm, under kikuyu pasture, 16 February 2000, sample 701, 20 cl, NMSA/Olig.02903 and sample 702, 8 cl + 23 juv, NMSA/Olig.02905. 10 April 2000: sample 709, 3 cl + 1 juv, NMSA/Olig.02910; sample 710, 3 cl + 5 juv, NMSA/Olig.02914; sample 711, 3 cl + 3 juv, NMSA/Olig.02917; sample 712, 2 cl + 4 juv, NMSA/Olig.02920; sample 714, 3 cl, NMSA/Olig.02926; sample 718, 3 juv, NMSA/Olig.02936; sample 721, 2 juv (one specimen very short), NMSA/Olig.02942; sample 722, 6 cl, NMSA/Olig.02946; sample 723, 1 cl, NMSA/Olig.02948; sample 725, 5 cl + 5 juv, NMSA/Olig.02953; sample 726, 6 cl + 7 juv, NMSA/Olig.02956; sample 727, 10 cl + 7 juv, NMSA/Olig.02959; sample 730, 18 cl + 20 juv, NMSA/Olig.02965; sample 732, 3 cl, NMSA/Olig.02970. Fairfield Farm, Field T, under banana trees, 1 March 2000: sample 309, 2 juv, NMSA/Olig.03074; sample 311, 2 cl (manifest regenerated segments in posterior part of the body), NMSA/Olig.03075. Fairfield Farm, under burnt cane, 1 March 2000, sample 214, 4 juv (minute specimens came out of cocoons during preservation), NMSA/Olig.03058. KwaMahleka Farm, 8 March 2000, from first 20 cm of soil covered by indigenous forest: sample 606, 1cl, very short, NMSA/Olig.03133; sample 607, 4 cl, NMSA/Olig.03134; sample 608, 3 cl, NMSA/Olig.03135. KwaMahleka Farm, under gum trees, 8 March 2000, sample 807, 1 cl, NMSA/Olig.03148. KwaMahleka Farm, under avocado trees, 8 March 2000, sample 1002, 1 cl, NMSA/Olig.02974; sample 1003, 1 cl + 1 juv, NMSA/Olig.02975; sample 1007, 1 juv, NMSA/Olig.02981. KwaMahleka Farm, under citrus trees, 8 March 2000, sample 413, 1 cl + 22 juv, NMSA/Olig.03107; sample 417, 18 juv (one specimen with a caudale zone on posterior part of the body), NMSA/Olig.03114; sample 419, 1 cl + 4 juv, NMSA/Olig.03116. Mistyridge Farm, veld, 22 March 2000, sample 506, 1 cl, NMSA/Olig.03124. Rockyridge Farm, indigenous forest, 15 March 2000, sample 611, 5 cl + 10 juv, NMSA/Olig.03139; sample 612, 2 cl + 7 juv, NMSA/Olig.03140. Rockyridge Farm, under gum trees, 15 March 2000, sample 809, 4 cl, NMSA/Olig.03150 and sample 812, 1 cl + 2 juv, NMSA/Olig.03152. 19 April 2000: sample 817, 1 cl, NMSA/Olig.03156; sample 820, 1 cl, NMSA/Olig.03159; sample 821, 3 cl + 3 juv, NMSA/Olig.03160. Rockyridge Farm, under pine trees, 19 April 2000: sample 1117, 1 cl + 1 juv, NMSA/Olig.03028; sample 1118, 1 juv, NMSA/Olig.03029; sample 1122, 1 cl, NMSA/Olig.03034; sample 1124, 1 cl, NMSA/Olig.03037. Eshowe-Entumeni: Fairfield Farm, under citrus trees, 23 February 2000, sample 404, 1 cl (very short), NMSA/Olig.03090. Mistyridge Farm, under pine trees, 22 March 2000, sample 1109, 1 cl + 4 juv, NMSA/Olig.03022; sample 1112, 2 cl + 1 juv, NMSA/Olig.03025. Rockyridge Farm, under pine trees, 15 March 2000, sample 1102, 2 cl + 2 juv, NMSA/Olig.02993; sample 1103, 2 cl + 1 abscised posterior part, NMSA/Olig.02995; sample 1104, 2 cl, NMSA/Olig.02997; sample 1101, 1 cl, NMSA/Olig.02992. Drakensberg, Rainbow Gorge [indigenous] Forest (28°54'S:29°05'E), 1950 m, above water catchment, on extended road from Mike's Pass, from soil & roots of grass dug out under young pine trees, 2 March 1989, JDP & BRS, 4 cl, NMSA/Olig.00256. Umlalazi Nature Reserve (28°59'S:31°44'E), from garden soil near tourist camp and office buildings, 2 February 1989, JDP & BRS, 1 cl, NMSA/Olig.00881. Gingindlovu (29°01'S:31°35'E), AJR, 17 cl + 20 juv, NMSA/Olig.01077. Inyczane River, near bridge on the Gingindlovu to Empangeni Rd, 8 May 1967, POL, 1 cl, NMSA/Olig.01279. Otto's Bluff (29°30'S:30°23'E), The Craig's Farm, on bank of local river, 6 December 1989, JDP, 1 juv, NMSA/Olig.00317. Pietermaritzburg (29°35'S:30°25'E): Chapel Str., December 1911, H. C. Burnup, 1 cl, NMSA/Olig.01066, 3 juv, NMSA/Olig.00283 [recorded in Michaelsen 1913]. Montrose, 2 Loveday Drive, from garden soil, 31 December 1988, JDP, 1 cl, NMSA/Olig.00202; 23 January 1989, JDP, 1 cl, NMSA/Olig.00204. Montrose, *ca.* 870 m, from garden soil, 3 October 1988, JDP, 3 juv, NMSA/Olig.00323. Mt. Michael, under tree, 28 November 1989, JDP, 3 cl, NMSA/Olig.00846. Scottsville, Sports-Fields near Alexandra Rd. from first 1–20 cm of moist, sandy soil, 14 February 1989, JDP, 2 cl + 4 juv, NMSA/Olig.00457. Sunnyside, road to Mt. Michael, Celtis Rd., from red soil and roots, 15 February 1989, JDP, 10 cl, NMSA/Olig.00993. Town Bush Valley, NPA Nursery, from black rich soil, 17 April 1989, JDP, 9 cl, NMSA/Olig.00973 and in wet soil between roots of various plants, 6 December 1989, JDP, 2 juv, NMSA/Olig.00979. Town Bush Valley, on left side road parallel to Queen Elizabeth Park Nature Reserve, from litter under bamboo tree, 24 January 1989, JDP, 13 juv, NMSA/Olig.00982. Commercial Rd., in front of Tatham Gallery, from flowerbed, 10 August 1995, JDP, 2 cl + 9 juv, NMSA/Olig.02120. Lower Tugela [Thukela], dam at Tongaat [29°35'S:31°08'E], under *Eucalyptus* tree, at 5 cm in black, sandy soil, deeper down sand, 9 May 1967, POL, 3 cl, NMSA/Olig.01280 [recorded in Ljungström 1972 under N10]. Inanda (29°36'S:30°55'E), about 3 miles from Mt. Edgecombe, on Umgeni road, sugarcane field, a few feet from edge of field, 10 May

1967, POL, 3 cl, NMSA/Olig.01281 [recorded in Ljungström 1972 under N11]. Ashburton (29º38'S:30º28'E), at edge grassland and garden, at 20 cm, 16 January 1989, JDP, 29 cl + 21 juv, NMSA/Olig.00791. Mount Edgecombe (29º42'S:31º02'E), sugarcane field, top 1–7 cm of moist, sandy soil, 12 January 1989, JDP, 2 juv, NMSA/Olig.00904. Inchanga (29º45'S:30º41'E), between roots of various plants, 20 May 1988, JDP, 4 cl + 5 juv, NMSA/Olig.00499. Durban (29º51'S:31º01'E) Stamford Hill: from garden soil, 8 May 1989, JDP, 24 cl + 60 juv, NMSA/Olig.00216; from garden, sandy soil, after rain, 20 February 1989, JDP, 31 cl, NMSA/Olig.01027 and 64 juv, NMSA/Olig.01028. Durban Westville, from compost soil, 6 March 1997, J. Palframan, 4 cl + 3 juv, NMSA/ Olig.02493. North Park Nature Reserve (29º52'S:30º52'E), 23 February 2001, collected by AJA & P. Ngwenya, forest, under log, 3 juv, NMSA/Olig.03345 and NMSA/ Olig.03346; forest, grassy glade, 3 cl + 3 juv, NMSA/Olig.03347; under leaf litter, 3 cl + 14 juv, NMSA/Olig.03348; at edge forest in thick medium-tall grass, 3 cl + 22 juv, NMSA/Olig.03351. Kenneth Stainbank Nature Reserve (29º54'S:30º55'E), 23 February 2001, AJA, under edge coastal forest patch, between grass roots, 5 cl + 7 juv, NMSA/ Olig.03341, 1 cl + 5 juv, NMSA/Olig.03342, 5 juv, NMSA/Olig.03343. Ixopo (30º09'S:30º05'E) area, 0.5 miles from Umzimkulu on Ixopo road, Hancock Grange 2017, grassfield, dark brown wet soil, at 0.5 cm, 15 May 1967, POL, 1 cl, NMSA/ Olig.01286 [recorded in Ljungström 1972 under N31]. Vernon Crookes Nature Reserve (30º16'S:30º35'E), collected by JDP, 4 km NE tourist camp, primary grassland, dug out by hand, 22 November 1989, 5 cl + 3 juv, NMSA/Olig.00757; 5 km W tourist camp, on bank small lake, 23 November 1989, 3 cl + 19 juv, NMSA/Olig.00843; 6 km N tourist camp, primary grassland, dug out by hand, 22 November 1989, 3 juv, NMSA/Olig.00762; bush area near tourist camp, from moist soil in close vicinity of large casts of *Microchaetus vernoni* Plisko, 1992, 8 March 1989, 9 cl, NMSA/Olig.00375; grassland, near small lake, 23 November 1989, 13 cl + 66 juv, NMSA/Olig.00838; primary grassland, from soil near path called 'north road', 22 November 1989, 1 cl + 1 juv, NMSA/Olig.00747; from vegetable garden near tourist camp, 8 March 1989, 12 cl + 6 juv, NMSA/Olig.00835. Umlazi [area], Amanzimtoti [30º03'S:30º53'E] Mission Reserve: near Adams Mission, Tiller station, extremely sandy soil, worms found on slope with wild grass, 10 May 1967, POL, NMSA/Olig.03189 [recorded in Ljungström 1972 under N14]; Adams Mission, in arable field [probably pasture], rich black soil, at Scottburgh [30º17'S:30º45'E] on Port Shepstone Rd., 17 October 1967, AJR & POL, 1 cl abscised, NMSA/Olig.01287 [recorded in Ljungström 1972 under N41]. Umzinto [30º18'S:30º39'E]: Glenrosa Station (Lot. 23), dam SW main road, approx. 7 miles from Umzinto on the Ixopo Rd, black, wet soil, 12 May 1967, POL, 1 cl, NMSA/ Olig.01285 [recorded in Ljungström 1972 under N24]; 1 mile from Park Rynie on Umzinto road, [probably pasture] black, sandy soil, worms down to 15 cm, 12 May 1967, POL, 2 cl, NMSA/Olig.01284 [recorded in Ljungström under N21]; at dam on coast road, 25 miles N Port Shepstone [30º 42'S:30º27'E]; [probably pasture] black clayey soil on sand,12 May 1967, POL, 2 cl, NMSA/Olig.01282 [on label: additional information 'approx. 15 miles N of Hibberdene']; [recorded in Ljungström 1972 under N 20]; at bank Ntskambili river 2 miles SW Umzumbe [30º37'S:30º33'E], 11 May 1967, POL, 2 cl, NMSA/Olig.01283. Oribi Gorge Nature Reserve (30º42'S:30º16'E) collected by JDP: at edge of sugarcane field, from wet, sandy soil, 22 May 1989, 10 cl, NMSA/ Olig.00223 and at *ca.* 550 m, from garden soil near rest camp, 22 May 1989, 1 cl (abscised posteriorly) NMSA/Olig.00892. Mbumbazi Nature Reserve (30°48'S:30°16'E) hillside, under tall grass, along road, 26 March 2001, collected by AJA & B. Kasseepursad, 2 cl, NMSA/Olig.03398. Mpenjati Nature Reserve (30°58'S:30°16'E), 28 March 2001, AJA & B. Kasseepursad, valley, tall higrophilous grass, 8 cl +7 juv, NMSA/Olig.03412; valley, medium-tall grass, 3 cl + 2 juv, NMSA/Olig.03415; valley, gardensoil outside Emthini Chalet, 1 juv, NMSA/Olig.03416.

Earlier published records:

SOUTH AFRICA: Michaelsen 1913: 422: *KwaZulu-Natal*: Durban, Umgeni, in plantation. Ljungström 1972: 7–8: *Kruger National Park*, Skukuza village, T16. *Northern Province*: Tzaneen [area], T19. Nelspruit T36. *KwaZulu-Natal*: Inyczane River, N3. Lower Tugela [Thukela area]: Stanger [29°30'S:31°17'E] N7; Etete River N9; Mdloti River N11. Inanda [29°36'S:30°55'E] [area], N12. Amanzimtoti [30°03'S:30°53'E] Mission Reserve, Adams Mission, N 15. Umgagaba [30°08'S:30°50'E] dam, N27. 1.5 miles from Park Rynie [30°19'S:30°44'E], N22. Reynolds & Reinecke 1976: 6–8: *Kruger National Park*: Matukwala, KNP2; Makoleke, KNP3; Skukuza [24°59'S:30°55'], KNP6; on Bumepad, KNP12; on road from Skukuza, KNP13, 14,17,19 & 23; Pafuri, KNP22; Mahlangene, KNP25; Skukuza Rest Camp, KNP27. [All collected on banks of rivers or near roads]. Zicsi & Reinecke 1992: 157: *Kruger National Park*: Skukuza. *Northern Province*: Nelspruit; White River [25°20'S:31°1'E]; Graskop [24°57'S:30° 52'E].

SWAZILAND: Reynolds 1993: 1–8: 3 km west of Pigg's Peak [*ca.* 25°55'S:31°15'E] under logs in stream bank; Ehlane Wildlife Sanctuary [*ca.* 26°15'S:31°50'E]; 2 km E Ezulwini [*ca.* 26°24'S:31°10'E]; Mliwane Game Sanctuary, [*ca.* 26°29'S:31°10'E] Ranger's house and granny's garden; Nsoko [*ca.* 27°05'S:31°58'E] stream bank.

Extralimital material:

In the Natal Museum Oligochaeta collection are also specimens of *P. corethrurus* from the following countries:

MADAGASCAR: Tananarive, [19°00'S:47°40'] at 1100 m, garden sandy clay with organic matter, 19 September 1996, S. T. Rarivonandrasana, 2 cl, NMSA/Olig.02461. SEYCHELLES ARCHIPELAGO: Cousine Island: [No more data given] March 1996, OB, 3 cl, NMSA/Olig.02321; from blackish soil (old swamp area) in banana plantation; less than 4 cm from surface, under banana leaf litter, 4 July 1995, OB, 5 cl + 4 juv, NMSA/Olig.02114; under granite rocks, 15 July 1995, OB, 4 juv, NMSA/Olig.02117; from rich litter humus on coarse soil mixed with humus, 1–3 cm below litter accumulated under *Ficus* canopy, 16 July 1995, OB, 2 cl + 2 juv, NMSA/Olig.02112; South ridge: under coconut husks litter, near surface, not more than 2 cm deep, 19 July 1995, OB, 4 cl + 4 juv, NMSA/Olig.02111; under *Pandanus* canopy and litter, *ca.* 3 cm under surface, 18 July 1995, OB, 8 juv, NMSA/Olig.02116.

DISCUSSION

P. corethrurus may prove to be the most widely introduced and established earthworm in the tropics and subtropics. Possibly it is also the one most subjected to experimental studies in laboratories and in the field. Literature on selected topics can be found in numerous papers (among others: Stephenson 1930; Gates 1972 1973; Righi & Bittencourt 1972; Righi 1984; Edwards & Bohlen 1996; Lavelle, Brussaard & Hendrix 1999). It is commonly accepted that its great adaptability under variable conditions is probably based on a high tolerance of a wide pH range, tolerance of disturbance of the pedological environment, and above all, parthenogenetic reproduction. This parthenogenesis is of great interest, although it is not known if biparental reproduction takes place in populations of the original range of the species. Spermatozoidal iridescence was observed in male funnels of only one British Guiana specimen, which may have been found near or in the original range of the species, but this does not confirm sexual reproduction of other members of that population (Gates 1973). All populations of *P. corethrurus* collected in South Africa were found to be parthenogenetic.

The material studied was collected in subtropical northeastern areas of South Africa (Fig. 1). The majority of occurrences were in the coastal zone and hinterland along the Indian Ocean, south of the tropic, extending near to 31ºS latitude.

In many other parts of South Africa where earthworms were looked for, the species was not found. Only 18 specimens in two samples were collected in Pretoria, about 600 km from the coast. However, both samples were found in close association with greenhouses: one juvenile specimen from under a potplant in a greenhouse, the other in soil of a flowerbed into which seedlings were transplanted from a greenhouse only two days before. I found no *P. corethrurus* material in the Pretoria area, in spite of intensive collecting of earthworms during 1977–1978. The species was not present in a collection gathered from Pretoria greens and sportfields by members of the University of Pretoria in 2000, which was sent to me for identification. No specimens of *P. corethrurus* were collected in southeast or southwest areas of the country, or south of the coastal zone of KwaZulu-Natal, although many other introduced species have been found.

Over 70% of the studied samples came from sites that were under direct agricultural practices (plantations of trees, sugarcane fields, pastures, garden soils and composting soil). To such localities the species could be directly or indirectly introduced: 22% were found in places influenced by the close proximity of humans (riverbanks, road verges, fallow grounds, and places under bridges); 7.33% were collected in indigenous forests or wooded sites, where exotic plants and other allochthonous earthworms also occurred. Co-existence between *P. corethrurus* and other exotic earthworms was widely observed, and dense populations were commonly noted in such localities. However, in the majority of sites *P. corethrurus* was limited to small coherent areas, and appeared to have a limited capacity for range expansion.

It would be expected that many earthworm introductions into South Africa would have taken place during the period when no quarantine precautions against introduced organisms were in force. Live worms and their cocoons could have been carried in containers conveying various plants, trees and shrubs, which were brought by ship to the various ports. The known range of *P. corethrurus* in South Africa (Fig. 1) suggests that importation of this species can possibly be attributed to plant introduction through the eastern, subtropical port of Durban, to which shipping traffic has come from far and wide. Introduced to KwaZulu-Natal, this species found a suitable environment, influenced climatically by the warm Indian Ocean. Subsequent dispersal in KwaZulu-

Natal, and to Mpumalanga, Kruger National Park and Northern Province, can be closely connected with environmentally favourable conditions and human activities. Nearly all records are from, or near, long-established urban settlements.

A passive transport of the species has evidently been the dominant factor affecting its distribution in South Africa. Van Bruggen (1964) observed that Mollusca introduced into South Africa probably arrived with plants. He found a correlation between the ages of the ports and the number of immigrant species in each, with the oldest port, Cape Town (founded in 1652), having the greatest number. The presence of such allochthonous species around the ports, and their subsequent spread to other areas, has been manifestly a consequence of human activities. It was also observed that some of the immigrant mollusc species, even those now broadly distributed, manifest a coherent pattern of occurrence linked to human activity.

The samples collected in the Drakensberg mountains of KwaZulu-Natal constitute an isolated occurrence near a Government Forestry Station, and the hotel at Cathedral Peak, both established in this area for many years. Although specimens were found in montane sites, including an isolated indigenous *Podocarpus* forest in a steep valley, in fact the presence of *P. corethrurus* can be attributed to accidental introduction, probably with pine (*Pinus* sp.) seedlings that were brought in and planted for experimental purposes in selected catchments during the 1950s. Slopes above that forest were among those planted. Large exotic trees in the gardens around the buildings of the Forestry Station also attest to the possibility of much earlier introductions. Similarly, the presence of *P. corethrurus* in limited areas of Gauteng, Mpumalanga and the Northern Province, is probably a consequence of the intensive development of plantations of *Pinus* and *Eucalyptus* species in subtropical montane areas with good, reliable rainfall, as well as of the 19th century growth of towns such as Nelspruit and Sabie, in the adjacent lowlands. Dispersal of *P. corethrurus* into the Kruger National Park can be ascribed to passive transport by water along rivers flowing eastwards from afforested montane areas and passing through these towns.

Although extensive collections of earthworms were made in other parts of South Africa, *P. corethrurus* was not found. It possibly failed to become established in them because of unsuitable climatic, pedological or other ecological factors. All the records listed above suggest strongly that *P. corethrurus*, while capable of exceptional adaptability to disturbed soils and a wide pH range, may be incapable of enlarging its range. The distribution pattern mapped in Fig. 1 suggests than climatic factors are limiting. These may include strong seasonal aridity, with dry winters in inland areas of South Africa, and the possibility of the occurrence of frost.

It is commonly accepted that *P. corethrurus* shows a high potential for crop improvement through its introduction into specific plant systems (for example seedlings, pastures, gardens). However, any contemplated introduction of *P. corethrurus* for the enhancement of soil fertility in areas where the endemic earthworm fauna would be detrimentally affected by disturbance, should take into account the limiting effects of climate. Experimentation is necessary to assess the ecological adaptability of this species on a wider geographical scale. More field-experiments, particularly long-term, in different regions under variable climatic conditions, and in various cropping systems, are needed to confirm that *P. corethrurus* could have a managed role in agricultural practices.

ACKNOWLEDGEMENTS

I am grateful to Dr J. G. H. Londt, Director of the Natal Museum, for access to the collection, and use of laboratory facilities. Many thanks are expressed to Prof. R. J. Haynes from the Faculty of Soil Science, University of Natal, Pietermaritzburg, for a recent presentation of the collection gathered by T. C. Dlamini, and also to Dr A. J. Armstrong for the material collected by members of the KwaZulu-Natal Nature Conservation Service, donated to the Natal Museum. Special appreciation and thanks go to Dr B. R. Stuckenberg, Director *emeritus* of the Natal Museum, for all his constructive comments on the paper, discussions and information on possible dispersion of earthworm species in South Africa. Thanks are extended to Dr D. Barraclough for his editorial input.

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